Space Weather Technical Forecast

Issued on Saturday, 15 June 2024 at 12:17 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of G1/minor geomagnetic storm Day 1 into Day 2 (15-16 Jun). Isolated M-class flares (R1-R2 radio blackouts) Likely throughout.

Analysis of Space Weather Activity over past 24 hours

Stop press: Shortly prior to issuing this document a CME arrived at L1 at 15/1102UTC – this is likely to be the awaited 12 June M1-associated event from AR3711. The solar wind at ACE rose to peak at a speed of near 450km/s, with the density reaching 10ppcc, the IMF peaking at 15nT, and the Bz at -14nT. A sudden impulse of 12nT was subsequently seen in the BGS Hartland magnetometer H-component at 15/1155UTC, along with a 26nT change in the four minutes from 15/1157UTC. The advertised slight chance of G2 appears unlikely given these measures.

A filament eruption was also observed on H-alpha imagery in the far southeastern quadrant. No coronagraph imagery is available for this event at the time of writing, however it is likely too far from the Sun-Earth line for any Earth-bound component.

Solar Activity: Activity remained Moderate with GOES16 recording an M1.3 peaking at 15/0627UTC from AR3712 in the southeast quadrant. This is the largest and most complex of up to seven sunspots on the current Earth-facing disc.

The nominally most complex and threatening groups all lie in the eastern solar hemisphere, and foremost amongst these is AR3712. This has at least one candidate for a Mt Wilson delta spot within it, and has undergone significant proliferation of its intermediate spots, with these developing penumbrae in the period and greatly increasing the overall area. Also of note is AR3716 in the northeast, which has also developed intermediate spots to become a compact group from its previously 'open' designation. Other groups were less noteworthy in the period, and amongst them is a newly-developed region in the northwest.

AIA304 imagery suggested there may have been a pair of filament lift-offs in the period, firstly in the north central disc at 14/2100UTC and secondly in the far southwest at 14/2200UTC. No Coronal Mass Ejections (CMEs) have been identified from either event. Coronagraph imagery otherwise showed some far-sided or low solar latitude CME candidates to no anticipated effect at Earth, and no new Earth-directed CMEs were in evidence.

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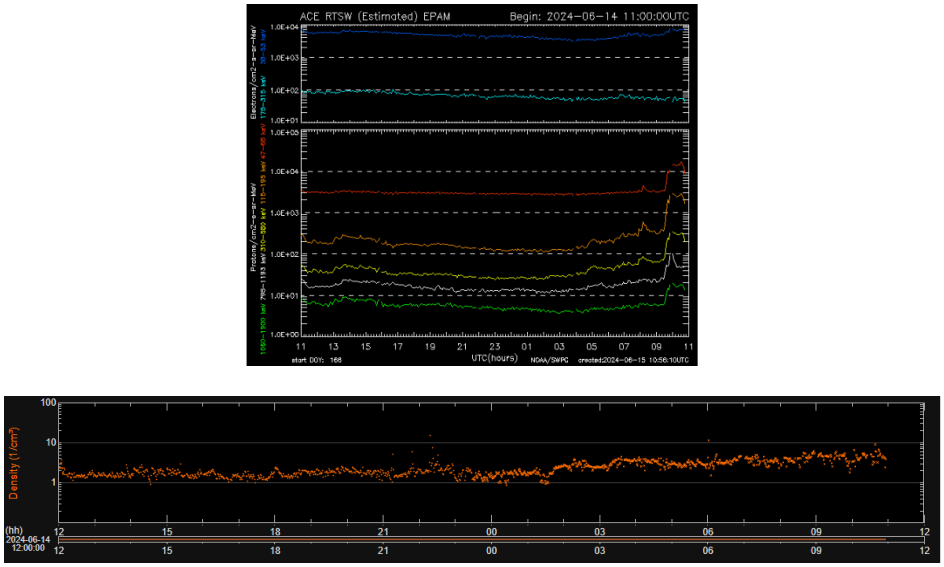

Figure 0: ACE EPAM LEMS as at 15/1100UTC showing rise across the low energy proton specturm that may be an early indicator of the 12 June CME (else perhaps a CIR leading CH45/+, although this would be very early). Also shown is 24 hours of ACE solar wind density at 15/1100UTC.

Solar Wind / Geomagnetic Activity: Solar winds, as observed by ACE at L1, were indicative of a slow regime, although the rising solar wind density trace and ACE EPAM LEMS evidence suggest that a feature is inbound, most likely the awaited 12 June CME or perhaps a CIR.

The solar wind speed was at Background levels, and showed a very gradual increase from 350 to 375km/s in the period. The aforementioned solar wind density was also within Background, but showing a rising trend within single figures ppcc. The IMF was low magnitude and relatively stable, with a peak within Background at 7nT, although the north-south component had a sustained anti-aligned tendency compared to Earth's field, with a range between -6 and +4nT. The phi angle was mainly negative (towards the Sun), but with increasingly frequent and lasting forays into positive territory as the period evolved.

The net result of the above solar wind measures was nevertheless provisionally Quiet, peaking either side of UTC midnight at Kp 2+.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux observed by GOES18 remained below the S1 threshold and is now very close to resting Background levels.

High energy electron flux (greater than 2MeV) observed by GOES16 was mainly at Normal Background levels, with the associated 24-hour fluence well below Active. Observed fluence at 15/0001UTC was 1.2e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Further isolated M-class flares are Likely, with a Slight Chance of X-class flares. Any significant flares remain most likely from AR3712 and AR3716 considering their complexity and growth. No significant regions are expected to depart or rotate onto the visible disc during the period.

Solar Wind / Geomagnetic Activity: A faint CME associated with a M1 flare at 12/2246UTC remains expected later on Day 1 or into Day 2 (UTC weekend, 15-16 June). Confidence is low regarding the arrival time and impact. A high speed stream from CH45/+ may connect to Earth during Day 3 (Monday 17 June) with uncertain enhancement, perhaps seeing winds increase to

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400-500km/s.

Initially Quiet geomagnetic activity should increase later Day 1 into Day 2 (15-16 June) upon arrival of the 12 June CME to Active or G1 (Kp4-5), with perhaps a Slight Chance of reaching Moderate/G2 (Kp6). Geomagnetic activity should then subside for a time, ahead of a possible return to Active into the UTC working week on arrival of any fast wind from CH45/+.

Energetic Particles / Solar Radiation: High energy proton flux is expected to very soon return to resting Background. The chances of new enhancements are low given the more complex spots showing a bias towards the less well-connecting eastern solar hemisphere for some days yet.

High energy electron flux is forecast to persist at predominantly Normal Background levels, and the associated 24-hour fluence is expected to remain below the Active threshold.

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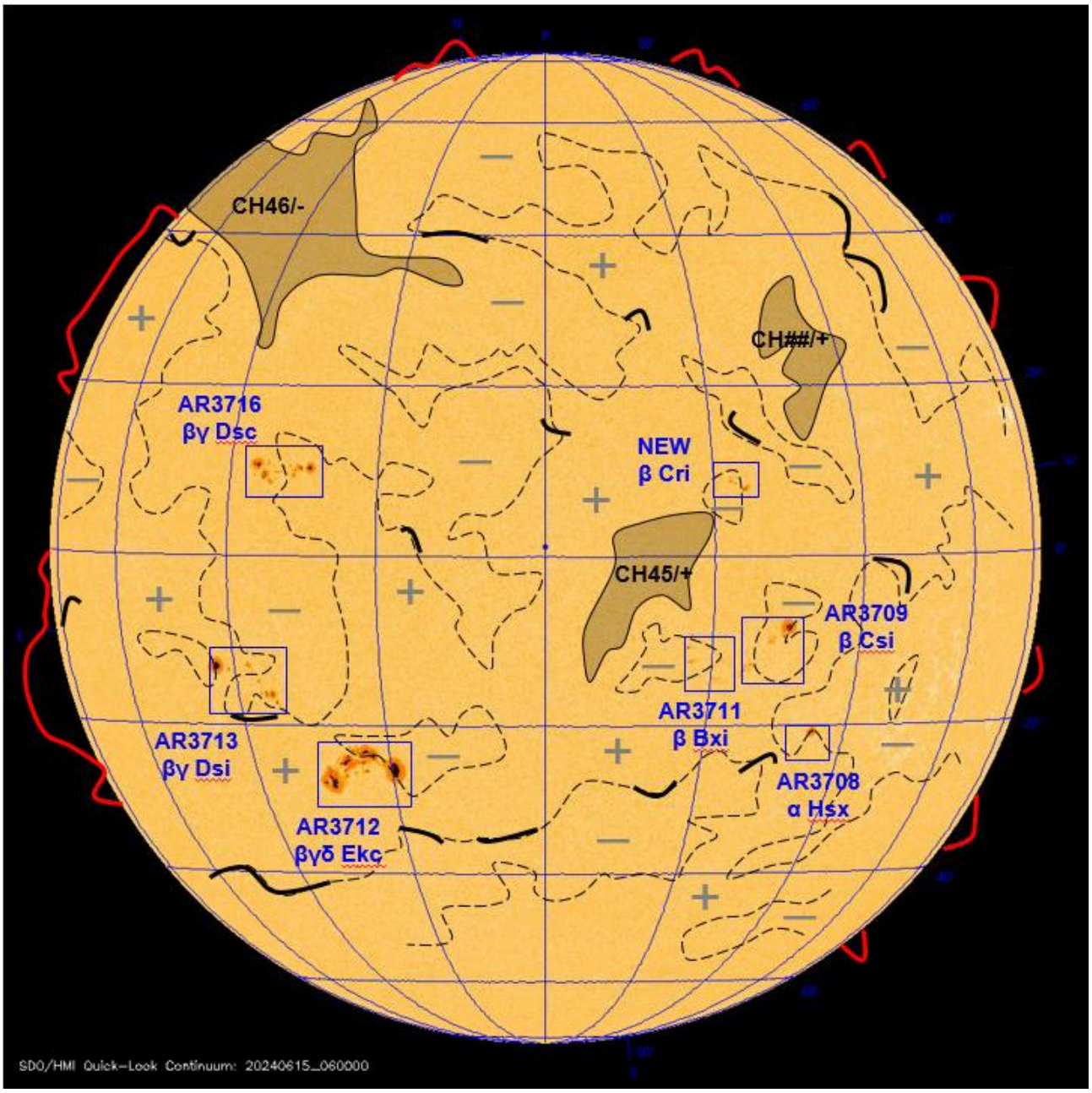
Figure 1. Solar Analysis Valid 15/0600UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

One CME features in the forecast period and is the dominant consideration in terms of geomagnetic activity. The inbound feature was emitted at 12/2246UTC from AR3711, and should cross 1AU and impinge on Earth's orbit later on Day 1 (15 June), or possibly into Day 2 (16 June). Confidence is low regarding the arrival time and impact, due to the weak nature of the CME and gaps in the imagery for analysis. Currently G1/Minor Geomagnetic storm intervals (Kp5) are anticipated.

One source of fast wind then rounds out the four-day forecast: CH45/+, which may connect with Earth on Day 3 (17 June). This feature is not recurrent and is therefore something of an unknown quantity, however due to our proximity to the solstice and CH45's limited visual (AIA211) size, solar wind speeds of 400-500 km/s are considered most likely. As a result, Unsettled or possibly Active (Kp3-4) geomagnetic intervals are possible. A faint unnumbered higher-latitude coronal hole feature that leads this hole by 20 degrees is not felt likely to feature in the forecast.

All considered, initially Quiet geomagnetic activity should increase to Active or G1 (Kp4-5) later Day 1 into Day 2 (15-16 June), with perhaps a small chance of reaching Moderate/G2 (Kp6) should it arrive on the near end of this time window. Geomagnetic activity should then subside for a time, ahead of a possible return to Active into the UTC working week on arrival of any fast wind from CH45/+.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	50	30	5	2
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
13/0131	Full	AR3711	SE quadrant	850km/s	15/1400UTC	Low confidence in arrival time.

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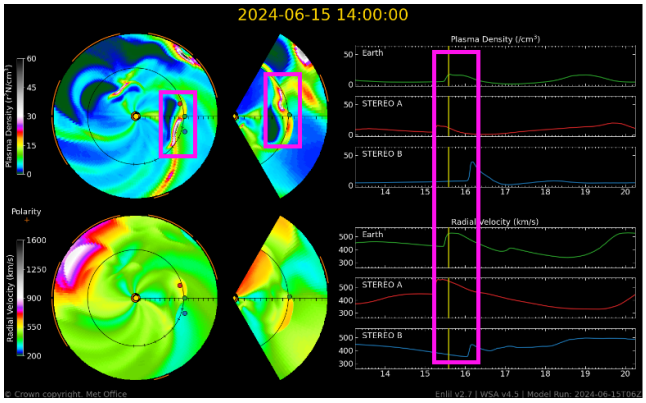
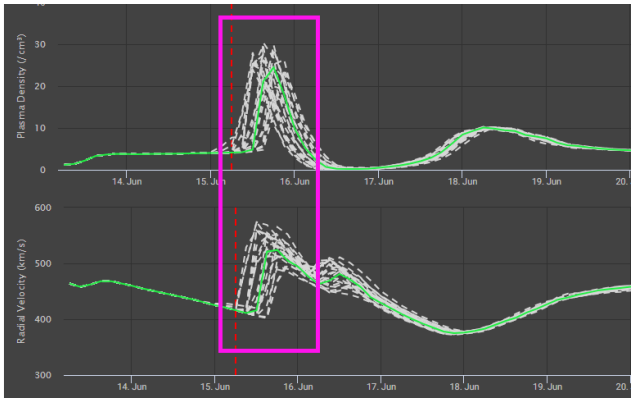
Figure 2: Latest MOSWOC Enlil run and ensemble, badge time 15/0600UTC pasued at the crossing of 1AU for the 12 June CME. MOSWOC Enlil is slightly overestimating solar wind speeds in the interplanetary medium at present, and is considered slightly late with CH45/+ effects, but overall the forecast envelope for CME arrivals appears realistic. At the time of writng the ACE EPAM LEMS trace and ACE solar wind density were both rising.





Radio Blackouts - X-Ray Flares:

The chances of significant flares have been revised upwards slightly on recent evidence of AR3712 and AR3716 both undergoing significant growth phases. Both of these sunspot groups now present as having 'compact' Zurich classifications, while AR3712 retains a Mt Wilson delta spot. All flare activity in the past 24 hours for C-class and above has emanated from one of these three regions, particularly AR3712.

In terms of the forecast, no significant sunspot regions either arrive or depart in the period, and the risk is therefore held constant for now, but with possible minor variation likely tied to the evolution of these groups.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**R1-R2 M Class**	Yes	60	60	60	60
Very Active	**R3 to R5 X Class**	No	5	5	5	5

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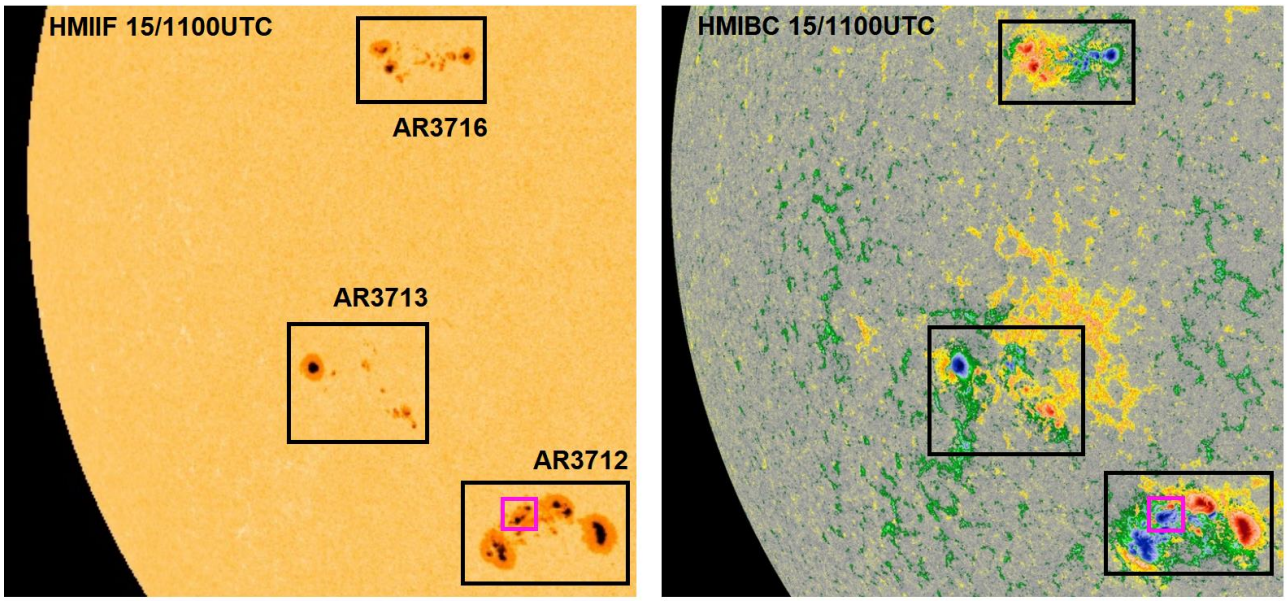
Figure 3: Imagery of eastern solar hemisphere sunspots. Also shown is Mt Wilson delta spot boxed in magenta.



Solar Radiation Storms - (High Energy Protons):

High energy proton flux is expected to soon revert to resting Background levels. In terms of the future risk, Ex-AR3697 continues to rotate further across the far side and the most significant regions on the visible disc are currently in the eastern solar hemisphere. The daily risk of surpassing S1 is therefore very low but shows a slight increase towards the end of the period as AR3612 moves into a more centrally-located position on the visible disc.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	10
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

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High Energy Electrons Event (≥ 2MeV):

The high energy electron flux is expected to persist at mainly Normal Background levels for much of this period, with limited significant sources of enhancement expected. Some diurnal Moderate flux values are likely.

The associated 24-hour fluence is expected to remain well below the Active threshold (1e8 integrated pfu). The inbound and potentially imminent CME should lessen the utility of MOSWOC REFM, however its current trend is considered to provide reasonably good guidance in the interim. The only other potential driver of increased counts at GEO is perhaps CH45/+, however any eventual fluence increase will come very late in this forecast period - if at all.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	1	10
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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